LIQUID-TIGHT CLOSURE
AND THE TREATMENT OF WOUNDS.

BY WALTER HERBERT TAYLOR, M.D., C.M. TOR.,
AND NORMAN BURKE TAYLOR, M.B. TOR., M.R.C.S. ENG.,
CAPTAINS, CANADIAN ARMY MEDICAL CORPS.

In the Lancet of Sept. 22nd, 1917, we described under this heading a device to render a wound water-tight during irrigation, and so dependably water-tight that any desired degree of positive or negative pressure might be employed. The device has now been improved and adapted with increasing success to many complicated features. It is no longer necessary to shave the part. There are now no exhaust tubes to get out of order. A shield of poroplastic felt is not required, the device being held on merely by an ordinary roller or many-tailed bandage. We have had several occasions given the device to one of the nursing sisters to apply, and she has been able to provide a water-tight closure and to flood and aspirate the wound in about the time she would have required to do a dressing.

This is the desideratum for which nearly two years we have striven to attain, yet hardly any effort would have seemed disproportionate to the want which to us appeared a very obvious one. The need of some means of providing liquid-tight closure has, perhaps, always existed.

Description of the Improved Device.

Figs. 1 and 2 are diagrammatic. The relative thicknesses of rubber are approximately correct as shown.

Fig. 2 shows the same more or less squeezed down by bandage pressure. In Fig. 2, when outflow is closed and inflow opened, the water pressure commences to accumulate, resulting in an expanding force between cover c (held down by bandage) and skin. This force also tends to squeeze between small lip LL and upper surface of small lip SL. It is obvious that a water-tight joint should result at juncture of small lip and skin. However, the water pressure acting upon inner surface of large lip LL might raise it like a curtain, allowing the pressure on small lip SL to buckle it out and underneath with consequent leakage. This difficulty has been overcome by applying the same pressure of fluid to outer as to inner aspects of large lip. We formed, external to the large lip, an annular chamber, c, bounded by thin bottom, d, thicker external wall, d', and corresponding portion of cover, c. This chamber communicates freely with main chamber by means of radiate xidges on broad top of large lip LL, ensuring circulation. The cover c is attached to top of thick vertical wall D.

The fluid in chamber B will neutralise the pressure in main chamber X, thus obviating lifting of large lip when pressure is increased. Pressure upon thin bottom D bolges it against skin; pressure against thick wall D', and a corresponding portion of cover c, will be reaturated by bandage.

Assuming that this device lies always on the skin, as the drawing indicates, leakage is evidently impossible. But so to devise it that its several parts will slide into position without buckling or kinking during its application, and afterwards to have them "stay put" during various alterations of pressure, muscular action, rolling in bed, etc., have been the chief difficulties, particularly since the changes in construction could not always be effected by the hands-working of rubber, but required a new steel mould to embody each improvement. Altogether we have tried and discarded over 50 different appliances. The increased efficiency presented by this form of device is due chiefly to the small lip being attached to a point below middle of large lip, so that during the eccentric spreading of the latter produced by bandage pressure the small lip is carried outward, too, and consequently placed upon the stretch. Its adaptability to different curved surfaces of body has been thereby enhanced. Its mechanical integrity was shown by subjecting it to a pressure of 20 feet when applied to an unwounded forearm. Such a pressure, of course, is not relevant to treatment of wounds.

Method of Use.

The technique of the application and use of the device is as follows:

No drainage-tubes are used in wound; these tend to block side pockets and to prevent thorough cleansing of granulating surfaces with which they come into contact. Furthermore, drainage-tubes as a means of conducting fluid into deeper depths of wound are superfluous, as fluid pressure beneath cover of device is continuous with that in wound. In some cases, however, when the wound contains, as seen in chronic sinus, a freer entrance to fluid and exit for pus may be provided by spreading lips of wound. For this purpose a small wire "cage" is used resembling a couple of hairpins with their loops joined at right angles. (Fig. 3.) The projecting free ends are bent over parallel to the skin.

The device is now applied with its centre coinciding roughly with centre of wound and bandaged to part. The bandage, preferably of cotton flannel, is added to the upper and lower margins of device, its pressure being snug and sufficient to produce collapse of vertical walls of appliance without constricting the part or causing discomfort. In cases where there is difficulty in moving the part a many-tailed bandage is most convenient. It is advisable, where possible, to place inner lip of apparatus out of contact with depressed scars or sharp elevations of skin. Where these cannot be avoided a little vaseline or a thick blanched paste will overcome the difficulty.

A glass reservoir capable of holding 3 to 5 pints adjustable to any level and provided with a small tube and clip should be ready to hand. The reservoir tube is now connected to smaller of two tubes issuing from the device. The larger or outflow tube arising from same is joined to a short length of tubing, which is pinched off and led into a waste-pail. The reservoir, filled with 5 per cent. saline at required level. The inflow tube is then opened, and space beneath cover allowed to fill with fluid. When level of fluid in reservoir has ceased to fall inflow should be closed and outflow opened. The ensuing establishment of negative pressure causes a "setting" of circumferential flanges of cover against skin.

The apparatus is now in readiness for institution of ebb-and-flow irrigation. (Fig. 4.)

Regulation of the Irrigation.

It is not possible at this time to lay down rules as to degrees of pressures and alternations to be employed in various types of wound. Each case must be judged upon its merits and the pressures graded accordingly. The avoidance of any pain, no matter how slight, is a guiding principle of the first importance.

Positive Pressure.

In all cases where there is much discharge pressures to start with should be low—usually from 6 to 12 inches as measured by height of column of fluid above level of wound. If no free pus issues from mouth of wound upon removal of device and little or none of it can be expressed by "milking" through its tracts pressure may be increased. It is doubtful whether it is ever necessary to go beyond 18 inches elevation above part, though the employment of higher pressures above this, even up to 3 feet, has in no way been associated with untoward effects.

Negative Pressure.

More care must be exercised in use of negative pressure. In old chronic sinus, even though discharging profusely, the maximum amount of negative pressure which height of ordinary military bed permit about 12 inches—may be used with impunity. In newly formed wound must be greatly reduced, and our one reliable criterion is the causation of pain, freedom from which indicates that amount of negative pressure is sufficient. Large "doses" of negative pressure produce a profound reaction in wound, and while this is salutary in chronic cases it possibly may be otherwise in an acutely inflamed wound.

In our earlier cases, mostly of chronic type, we underestimated the potential of negative pressure, and were much puzzled by the occurrence of slight initial rise of temperature (2°-3°) after device had been in operation for a few hours. This rise ran parallel to marked cleansing and freshening of wound, and notable improvement of all.
local signs, it struck us in the light of a phenomenon, until the same
previously pouring pus. was found filled with lymph and blood; there
negative pressure became rather too evi ient. In this case patient had
complained of pain; nevertheless, in a few hours the wound opening,
upon pouring out of lymph and extravasation of blood, with their
rise of tempera'ure as being of a reactionary nature and consequent
abolished until the more urgent symptoms subside. To measure its
duration of negative be just sufficient to freshen solution in wound
(about 10 seconds).

Alternations of Pressure

The variations between positive and negative pressures are accom-
monly interfered with by the patient, depending on the particular features of the case.

At commencement, and until effective drainage becomes fairly
complete, positive and negative pressures may be alternated by 3
minutes each, or 15 minutes positive and 5 to 10 minutes negative. After
this, positive pressure is prolonged to an hour or so or an ultimate
of negative adapted to type of wound, being long in chronic and
short in acute cases. As a general rule the duration of negative pres-
sure should not exceed 5 minutes, and never be long enough to pro-
duce pain. These alternations may be regulated by patient during waking hours and, for convenience,
be prolonged during the periods of positive pressure to be just sufficient to freshen solution in wound (about 10 seconds).

A wound with counter-opening should be treated by application of two devices. The device covering main wound should have its outflow tube occluded by short length of glass rod for comfort of case. The device covering counter-opening should have its inflow occluded in same way. Thus through-and-through cleansing of duration of disease is obtained. It will be convenient to have devices for application to counter-openings made much smaller and furnished with outflow tube only. This application of the method is particularly useful in the treatment of joints.

In employment of device in empyema, positive pressure should be
very low and its periods be of short duration. The negative pressure excreted in intervals should equal that of normal pleural cavity—i.e., about a 3-inch column of water. Extents of increased to encourage lung expansion we do not know, but as much as 15 inches has been used without ill-effects. The device should be bandaged to chest during expiration.

After irrigation with hypertonic saline has been in operation 4 to
10 days—according to severity of condition—we are in the habit of removing device for two or three hours. If no pus appears, clear lymph and blood alone occupying mouth of wound, the device is reapplied and irrigation continued with an antiseptic solution for 48 hours, its bleb being to effect a final sterilisation. Lately we have been using a 1 in 3,000 solution of divine in hypertonic saline.

Results.

Certain phenomena have been observed to follow so const-
antly the employment of this method of irrigation that we are able now to predict their appearance. Though our initial impressions as yet have been largely banished, the form of "stagnated indurated tissues and return to normal colour.

2. Establishment during negative pressure of outward flow of lymph with, or without, an accumulation of pus. This, in our cases, was improvement in general appearance, less swelling and tenderness, and yet temperature was elevated. We came to look upon this rise of temperature as being of a reactionary nature and consequent
3. Avoidance of large mutilating incisions required for evacu-

...